

one dimension of about 10 micrometers. In some embodiments, the working electrode **620** is a microelectrode with at least one dimension less than 10 micrometers. The thickness (e.g., height on the substrate) can be 1 micrometer or less. The thickness dimension can be, for example, between about 1 micrometer and about 50 nanometer, such as approximately 500 nanometers, approximately 250 nanometers, approximately 100 nanometers, approximately 50 nanometers, etc. For example, the bar-shaped working electrode **620** can be a conductive material patterned on a substrate to have a width of about 25 micrometers, a length of about 1000 micrometers, and a thickness of about 0.5 micrometers. In some embodiments, the reference electrode **622** can be larger in area (e.g., length multiplied by width) than the working electrode **620**. For example, the reference electrode **622** have an area more than five times greater than the area of the working electrode **620**.

[0086] The electrodes **620**, **622** can each be formed by patterning conductive materials on a substrate (e.g., by deposition techniques, lithography techniques, etc.). The conductive materials can be gold, platinum, palladium, titanium, silver, silver-chloride, aluminum, carbon, metals, conductors formed from noble materials, combinations of these, etc. In some embodiments, the working electrode **620** can be formed substantially from platinum (Pt). In some embodiments, the reference electrode **622** can be formed substantially from silver silver-chloride (Ag/AgCl).

[0087] The electrodes **620**, **622** are each electrically connected to a potentiostat **610** which operates the sensor **601** by applying a voltage difference ΔV between the working electrode **620** and the reference electrode **622**. The voltage difference ΔV can be a reduction voltage sufficient to cause a reduction reaction at the working electrode **620** that releases electrons from the working electrode **620** and thereby generates an amperometric current that can be measured through the working electrode **620**. Additionally or alternatively, the voltage difference ΔV can be an oxidization voltage sufficient to cause an oxidization reaction at the working electrode **620** that contributes electrons to the working electrode **620** and thereby generates an amperometric current that can be measured through the working electrode **620**. The potentiostat **610** is powered by a supply voltage V_{supply} and outputs an indication of the amperometric current.

[0088] FIG. 6B illustrates another example arrangement for electrodes in an electrochemical sensor **602**. The arrangement illustrated by FIG. 6B is not drawn to scale, but instead is provided for explanatory purposes to describe the example arrangement. The electrochemical sensor **602** can be included in an eye-mountable device for detecting tear film oxygen concentrations and/or other analytes (e.g., the eye-mountable devices described in connection with FIGS. 1-3 above). The electrochemical sensor includes a working electrode **630** and a reference electrode **632** arranged as flattened rings situated on a substrate. The flattened rings can be arranged concentrically (e.g., with a common center point) such that the separation between the electrodes **630**, **632** is substantially uniform along the circumferential edges of the respective electrodes **630**, **632**. The reference electrode **632** is illustrated as an outer ring, with the working electrode **630** as an inner ring, but this inner/outer relationship can be reversed in some implementations. In some embodiments, at least one of the dimensions of the working electrode **630**, such as its radial width, can be less than 100 micrometers. In some embodiments, the working electrode **630** is a microelectrode with at

least one dimension of about 25 micrometers. In some embodiments, the working electrode **630** is a microelectrode with at least one dimension of about 10 micrometers. In some embodiments, the working electrode **630** is a microelectrode with at least one dimension less than 10 micrometers. The thickness (e.g., height on the substrate) can be 1 micrometer or less. For example, the flattened-ring-shaped working electrode **630** can be a conductive material patterned on a substrate to have a circumference of about 1000 micrometers, a radial width of about 25 micrometers, and a thickness of about 0.5 micrometers.

[0089] The electrodes **630**, **632** can be formed by the materials and patterning techniques described above in connection with the electrodes **620**, **622** in FIG. 6A. The electrodes **630**, **632** can also be operated by the potentiostat **610** to measure an amperometric current similarly to the discussion of the potentiostat **610** above in connection with FIG. 6A.

[0090] FIG. 7A illustrates an example coplanar arrangement for electrodes in a two-electrode electrochemical sensor. In this configuration, the two electrodes, a working electrode **720** and a reference electrode **722**, are mounted on a substrate **730** that is covered by a layer of polymeric material **710**. In FIG. 7A, the portion **711** of the polymeric material **710** that covers electrodes **720** and **722** is indicated by dashed lines in order to show electrodes **720** and **722**. Thus, in this example, the two-electrode electrochemical sensor includes a working electrode **720** and a reference electrode **722** that are mounted on the same surface of substrate **730**, and polymeric material **710** forms a layer encapsulating both the working electrode **720** and the reference electrode **722**. For example, the substrate **730** can be shaped as a flattened ring suitable for being mounted within an eye-mountable polymeric material, similar to the substrates described above in connection with FIGS. 1-5. The polymeric material **710** can have an exposed surface **714** that is suitable for contact mounting to an eye, similar to the concave surface **226** of the eye-mountable device **210** discussed above in connection with FIG. 2. The exposed surface **714** can also be suitable for avoiding interference with eyelid motion while an opposing surface of the polymeric material is contact mounted to an eye, similar to the convex surface **224** of the eye-mountable device **210** discussed above in connection with FIG. 2. Thus, the electrodes **720**, **722** can be mounted to an eye-facing surface and/or an outward facing surface of the substrate **730**.

[0091] The electrodes **720**, **722** can each be formed by patterning conductive materials on a substrate (e.g., by deposition techniques, lithography techniques, etc.). The conductive materials can be gold, platinum, palladium, titanium, silver, silver-chloride, aluminum, carbon, metals, conductors formed from noble materials, combinations of these, etc.

[0092] As shown in FIG. 7A, the working electrode **720** has a width w_1 and the reference electrode has a width w_2 . The width w_1 of the working electrode **720** can be, for example, less than 25 micrometers. In some embodiments, the width w_1 can be about 10 micrometers. In some embodiments, the width w_1 can be less than 10 micrometers. The width w_2 can be selected such that the area of the reference electrode **722** (e.g., width w_2 multiplied by length) is at least five times greater than the area of the working electrode **720** (e.g., width w_1 multiplied by length). The lengths of the two electrodes **720**, **722** can be approximately equal and can be, for example, 1 millimeter. The height ("thickness") of the electrodes **720**, **722** can be, for example, about 0.5 micrometers. Where the lengths of the two electrodes **720**, **722** are approximately